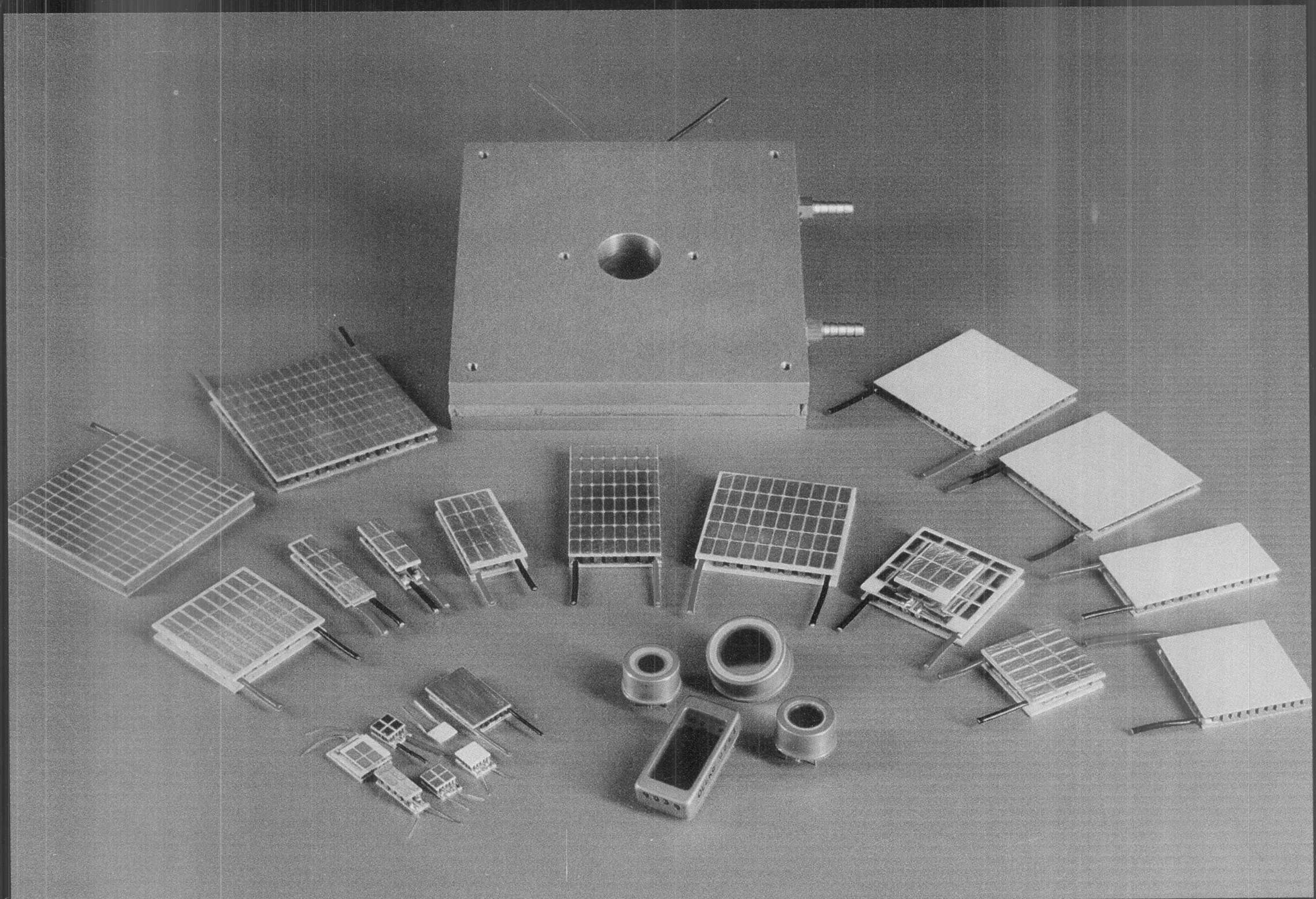
Thermoelectric
Heating & Cooling Modules

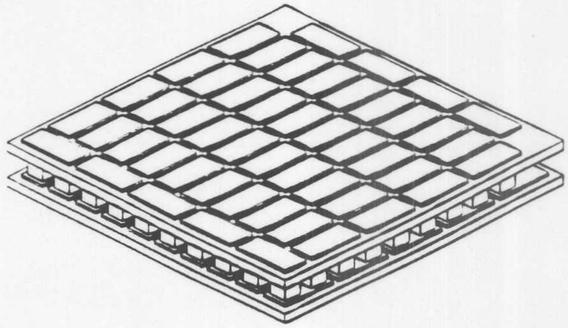
INNOVATIONS IN THERMAL TECHNOLOGY



ThermoTrex Corporation

PRODUCT DEVELOPMENTS

*T**hermoTrex Corporation* (*TTC*) develops, and manufactures a complete line of thermoelectric products with advanced technology in electro-optic and electro-acoustic systems, signed processing, materials technology, lasers, thermionics and thermoelectric direct-energy conversion devices. *TTC* also manufactures and markets imaging systems for early detection of breast cancer.



ThermoTrex Corporation is a public subsidiary of *Thermo Electron Corporation.*, which is a world leader in environmental monitoring and analysis instruments and a major manufacturer of biomedical products including heart-assist devices and mammography systems, and other specialized products. The company also provides environmental and metallurgical services and conducts advanced technology research and development. With annual world sales of more than $1 billion, *Thermo Electron* has 8,500 employees and operations in 14 countries.

This catalog covers the bismuth telluride thermoelectric heating/ cooling modules. At the foundation of today's thermoelectric technology is the Peltier effect. In 1834 Jean C. A. Peltier discovered that the passage of an electrical current through the junction of two dissimilar conductors resulted in a change in the junction's temperature.

Our thermoelectric devices are technically superior products for applications requiring cooling capabilities in ambients of -50°C and up to +125°C. Mechanical capabilities will withstand temperatures of -50°C up to 150°C/ 220°C.

The thermoelectric department at *TTC* is dedicated to the development of advanced thermoelectric materials for both heating/cooling and power generation devices. The principal goals are to create innovative ideas and concepts for the thermoelectric industry.

ThermoTrex Corporation

SOLID STATE THERMOELECTRIC HEAT PUMPS

Thermoelectric modules are solid state devices which function as heat pumps when a DC current is passed through them. They can either heat or cool depending on the direction of the current flow.

Thermoelectrics are used in a variety of applications, such as:

- Maintaining temperature of a laser diode
- Infrared devices
- Wafers probing stations
- CCD imaging arrays
- Avalanche photodiodes
- Black body references
- Medical test equipment
- Missile and space applications
- Temperature control of electronic packages and components
- Constant temperature baths
- Parametric amplifiers
- Portable refrigeration
- Laboratory cold plates
- Air pollution analyzers
- Power generation

Advantages of using Thermoelectric modules are as follows:

- Heating or cooling, the same device by simply reversing the direction of current to the thermoelectric
- Solid state
- High reliability operation in harsh environments
- Operation from DC instead of AC
- Precision temperature control below and above ambient
- Localized cooling
- Minimal electrical noise
- Fast response time
- Reduced space, size and weight
- No acoustic noise
- No CFC's or compressed gases.

ThermoTrex not only manufactures and designs a standard product offering, but also specializes in custom designs to suit your particular requirements. Please contact our engineering department today with your requirements and we will be happy to assist you.

ThermoTrex Corporation

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SOLID STATE THERMOELECTRIC HEAT PUMPS

Solid State Thermoelectric Heat Pumps

Thermoelectric devices function as solid-heat pumps. With a suitable application of electric current, they can either heat or cool. Users can increase the temperature differentials by cascading the devices thermally in series, and can increase the heat pumping capacity by connecting the devices thermally in parallel. If subjected to an externally applied temperature gradient the devices will in turn generate electric power.

Our thermoelectric devices are used for applications requiring cooling in ambients of -50°C and up to 125°C. Mechanical capabilities will withstand temperatures of -50°C up to 150°C/220°C.

Our applications department will be glad to assist you with your specific requirements.

Part Number	Q_{max} watts	I_{max} amps	Volts	Max Temp. Limit °C	Base Ceramic Length (in)		Base Ceramic Width (in)		Top Ceramic Length (in)		Top Ceramic Width (in)		Height (in)	
					(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
00501-9G21-04B	1.4	4.0	0.65	210	0.60	15.24	0.19	4.82	0.52	13.20	1.94	0.83	0.185	4.70
00601-6LX1-09B	3.5	9.0	0.7	160	1.10	27.94	0.03	7.62	0.90	22.86	0.30	7.62	0.208	5.28
00711-6LX1-04B	1.8	4.0	0.8	160	0.81	20.57	0.20	5.08	0.70	17.78	0.20	5.08	0.170	4.32
00711-6LX1-06B	2.7	6.0	0.8	160	0.81	20.57	0.20	5.08	0.70	17.78	0.20	5.08	0.170	4.32
01111-6LX1-04B	3.0	4.0	1.4	160	1.17	29.72	0.20	5.08	1.17	29.72	0.20	5.08	0.170	4.32
01111-6LX1-06B	4.0	6.0	1.4	160	1.17	29.72	0.20	5.08	1.17	29.72	0.20	5.08	0.150	3.81
01511-6LX1-04B	4.0	4.0	2.0	160	1.65	41.92	0.20	5.08	1.65	41.92	0.20	5.08	0.185	4.70
01511-6LX1-06B	6.0	6.0	2.0	160	1.65	41.92	0.20	5.08	1.65	41.92	0.62	15.75	0.208	5.28
01501-9LX1-09B	9.5	9.0	2.0	210	1.25	31.75	0.62	15.75	1.25	31.75	0.62	15.75	0.208	5.28
01501-9LX1-14B	14.0	14.0	2.0	210	1.25	31.75	0.62	15.75	1.25	31.75	0.62	15.75	0.208	5.28
06311-6LX1-04B	16.0	4.0	8.0	160	1.65	41.92	0.82	20.83	1.65	41.92	0.82	41.92	0.185	4.70
01801-6G21-11B	1.3	1.1	2.4	160	0.31	7.87	0.24	6.10	0.24	6.10	0.24	6.10	0.106	2.69
01801-6G21-18B	2.1	1.8	2.4	160	0.31	7.87	0.24	6.10	0.24	6.10	0.24	6.10	0.092	2.34
01801-9G21-11B	1.3	1.1	2.4	210	0.31	7.87	0.24	6.10	0.24	6.10	0.24	6.10	0.106	2.69
01801-9G21-18B	2.1	1.8	2.4	210	0.31	7.87	0.24	6.10	0.24	6.10	0.24	6.10	0.092	2.34
02401-6LX1-09B	14.0	9.0	3.0	160	1.50	38.10	0.75	19.05	1.50	38.10	0.75	19.05	0.208	5.28
02401-9LX1-09B	14.0	9.0	3.0	210	1.50	38.10	0.75	19.05	1.50	38.10	0.75	19.05	0.208	5.28
02401-9LX1-14B	23.0	14.0	3.0	210	1.50	38.10	0.75	19.05	1.50	38.10	0.75	19.05	0.208	5.28
02801-6LX1-09B	18.0	9.0	4.0	160	1.81	45.97	0.48	12.19	1.68	42.67	0.48	12.19	0.208	5.28
02801-9LX1-09B	18.0	9.0	4.0	210	1.81	45.97	0.48	12.19	1.68	42.67	0.48	12.19	0.208	5.28
03101-6LX1-09B	20.0	9.0	4.0	160	1.25	31.75	1.25	31.75	1.25	31.75	1.25	31.75	0.208	5.28
03101-9LX1-09B	20.0	9.0	4.0	210	1.25	31.75	1.25	31.75	1.25	31.75	1.25	31.75	0.208	5.28
03101-9LX1-14B	29.0	14.0	4.0	210	1.25	31.75	1.25	31.75	1.25	31.75	1.25	31.75	0.208	5.28
03501-6LX1-04B	8.0	4.0	4.5	160	1.17	29.72	0.58	14.73	1.17	29.72	0.58	14.73	0.170	4.32
04101-6LX1-27B	7.2	2.7	5.3	160	0.75	19.05	0.47	11.94	0.75	19.05	0.45	11.43	0.150	3.81
04901-6LX1-09B	29.0	0.9	0.6	160	1.50	38.10	1.50	38.10	1.50	38.10	1.50	38.10	0.208	4.32
04901-9LX1-09B	29.0	9.0	6.0	210	1.50	38.10	1.50	38.10	1.50	38.10	1.50	38.10	0.208	3.81
04901-9LX1-14B	45.0	14.0	6.0	210	1.50	38.10	1.50	38.10	1.50	38.10	1.50	38.10	0.208	5.28
06201-6LX1-09B	37.0	9.0	8.0	160	1.96	49.79	0.98	24.89	1.96	49.79	0.98	24.89	0.208	5.28
06201-9LX1-09B	37.0	9.0	8.0	210	1.96	49.79	0.98	24.89	1.96	49.79	0.98	24.89	0.208	5.28
07111-6LX1-04B	17.0	4.0	9.0	160	1.17	29.72	1.17	29.72	1.17	29.72	1.17	29.72	0.170	4.32
07111-6LX1-06B	28.0	6.0	9.0	160	1.17	29.72	1.17	29.72	1.17	29.72	1.17	29.72	0.150	3.81
07111-9LX1-04B	17.0	4.0	9.0	210	1.17	29.72	1.17	29.72	1.17	29.72	1.17	29.72	0.170	4.32
07111-9LX1-06B	28.0	6.0	9.0	210	1.17	29.72	1.17	29.72	1.17	29.72	1.17	29.72	0.150	3.81
09401-6LX1-09B	57.0	9.0	12.0	160	1.96	49.79	1.46	37.08	1.96	49.79	1.46	49.79	0.208	5.28
09401-9LX1-09B	57.0	9.0	12.0	210	1.96	49.79	1.46	37.08	1.96	49.79	1.46	49.79	0.208	5.28
12601-6LX1-09B	75.0	9.0	16.0	160	1.96	49.78	1.96	49.78	1.96	49.78	1.96	49.78	0.208	5.28
12601-9LX1-09B	75.0	9.0	16.0	210	1.96	49.78	1.96	49.78	1.96	49.78	1.96	49.78	0.208	5.28
12711-6LX1-04B	33.0	4.0	16.0	160	1.65	41.92	1.65	41.92	1.65	41.92	1.65	41.92	0.185	4.70
12711-6LX1-06B	50.0	6.0	16.0	160	1.65	41.92	1.65	41.92	1.65	41.92	1.65	41.92	0.165	4.19
12711-9LX1-04B	33.0	4.0	16.0	210	1.65	41.92	1.65	41.92	1.65	41.92	1.65	41.92	0.185	4.70
12711-9LX1-06B	50.0	6.0	16.0	210	1.65	41.92	1.65	41.92	1.65	41.92	1.65	41.92	0.165	4.19
12711-5ZX1-06R	50.0	6.0	16.0	90	1.56	39.62	1.56	39.62	1.56	39.62	1.56	39.62	0.145	3.68

DESIGN EXAMPLE

■ EXAMPLE:

A laser generates 2 watts of heat. It is desired to maintain this laser at 20°C. The ambient temperatures is 40°C.

■ Heat Load Determination(Q_T)

$Q_T = Q_A + Q_{HL}$

(Q_A)Heat generation	2.0 Watts
(Q_{HL})Heat leak	0.3 Watts
Q_{Total}	2.3 Watts

■ Heat Sink Temperature Section

In all cases some form of a heat sink is required to remove the heat that the thermoelectric module has pumped from the laser ($Q_h = Q_T + P$). The heat sink is most critical to the design of the thermoelectric system, The smaller the temperature differential ($\Delta T = T_H - T_C$) across the module the more efficient the modules becomes.

In this example a heat sink with a thermal resistance of 1.8°C/watt has been chosen. With this value the heat sink will probably rise 10° C above ambient because we will have approximately 5 watts ($Q_h = Q_T + P$) of heat going into the heat sink. This factor is explained below.

■ Summary of Factors

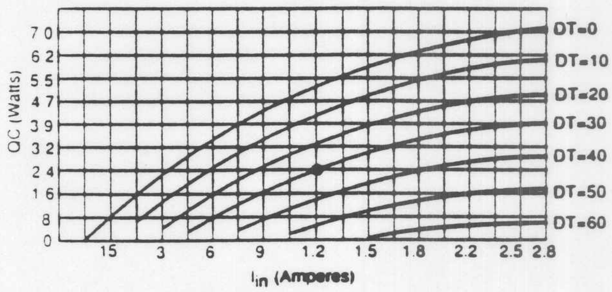
Q_T = 2.3 Watts
T_C = 20°C
T_a = 40°C
T_h = 50°C (40°C + 10°C)
ΔT = 30°C (T_h - T_C) across the thermoelectric module.

■ Solution of Factors

Part #04101-6LX1-27B has been selected as a possible solution to this problem.

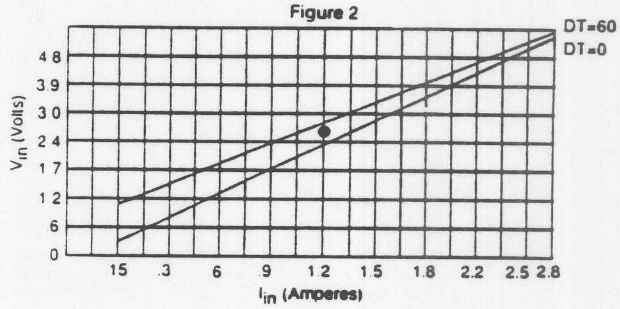
In Fig. 1, the heat pumping power (Q_C), ΔT, and amperage can be determined. The point on the graph refers to ΔT of 30°C. At that point,
The current is = 1.2 amps and Q_C = 2.4 watts.

Figure 1



In Fig. 2, the input power of the module can be determined. The point on the graph refers to ΔT of 30°C. At that point, the current is 1.3 amps and the voltage = 2.5 volts.
$P_T = I \bullet V = (1.2)(2.5) = 3.0$ Watts.

Figure 2



Summary of problem and solution

Problem: Q_T = 2.3 Watts
T_a = 40° C,Tc =20 °C
T_h = 50° C and ΔT = 30 °C

Solution: Part #HP 04101-6LX1-27B
At a 30° ΔT I_{in} = 1.2 amps, V_{in} = 2.5 volts
P_{in} = 3.0 Watts
Q_T = 2.3 Watts
Q_h = 5.3 Watts

Thermal resistance required for the heat sink =

$$\frac{T_h - T_a}{Q_h} = \frac{10°C}{5.4\ W} = 1.85°C/W$$

If any questions arise concerning your application,our engineering department will be glad to assist you at (617) 622-1391.
Fax # (617) 622-1027

HEAT TRANSFER INFORMATION

A. Time Required to Change the Temperature of an Object.

$$T = \frac{m\, Cp\, \Delta T}{Q}$$

Where:
- T is the time interval in hours.
- Cp is the average specific heat of the material in BTU/lb °F.
- m is the weight of the material in lbs.
- ΔT is the temperature change of the material in °F.
- Q is the heat added or removed in BTU/hr.

NOTE: because thermoelectric modules remove heat at a variable rate with a changing ΔT, the value of Q in this formula should be calculated as follows:

$$Q = \frac{(Q_C \text{ at } \Delta T \text{ min}) + (Q_C \text{ at } \Delta T \text{ max})}{2}$$

B. Heat Leakage Through the Walls of an Insulated Container

$$Q = A \left(\frac{\Delta T}{\frac{X}{K} + \frac{1}{h}} \right)$$

Where:
- Q is the heat leakage in BTU/hr.
- A is the external surface area of the container in square feet.
- ΔT is the temperature between inside and outside of container in °F.
- K is the average heat transfer coefficient in BTU/hr-ft-°F.
- h is the average heat transfer coefficient in BTU/hr-ft^2-°F. (Typical value = 5)
- X is the insulation thickness in feet.

C. Heat Leakage from an Exposed Surface to Ambient by Convention

$$Q = hA\Delta T$$

Where:
- Q is the heat leakage in BTU/hr.
- h is the heat transfer coefficient in BTU/hr-ft^2°F. (Typical value = 5)
- ΔT is the temperature difference between the exposed surface and ambient in °F.

D. Miscellaneous Relationships

1 Watt	=	3.413 BTU/hr
1 BTU/hr	=	0.293 Watts
°F	=	9/5(°C + 32)
°C	=	5/9(°F - 32)
1 in^2	=	0.00694 ft^2
1 gm	=	0.002205 lbs
1 gm/cm^3	=	62.43 lbs/ft^3
1 cm	=	0.3937 in = 0.03281 ft
1 liter	=	0.2642 gallons
1 mm	=	0.0397 inches

E. Typical Properties of Various Materials

MATERIAL	ρ Density lb/ft^3	K Thermal Conductivity BTU/hr-ft°F	Cp Specific Heat BTU/lb-°F
AIR	0.074	0.015	0.24
ALUMINUM	169	118	0.214
BRASS	530	64	0.38
COPPER	559	223	0.092
IRON/STEEL	485	30	0.11
NICKEL	556	52	0.107
POLYURETHANE	1.8	0.002	0.27
STAINLESS STEEL	500	10	0.11
WATER	62.4	0.08	1.00

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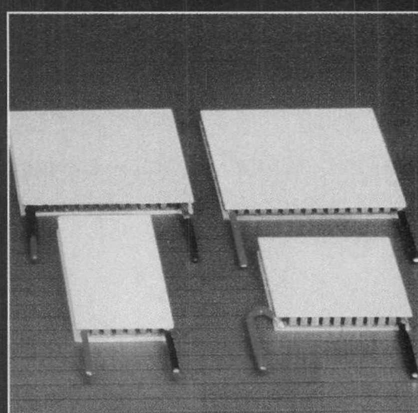
CONVERSION TABLE

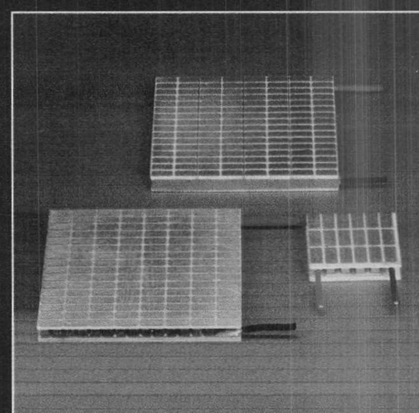
-40 TO 15			16 TO 35			36 TO 55			56 TO 75			76 TO 95			96 TO 220		
C.	C.orF.	F.	C.	C.orF.	F.	C.	C.orF.	F.	C.	C.orF.	F.	C.	C.orF.	F.	C.	C.orF.	F.
-40.0	-40	-40	-8.89	16	60.8	2.22	36	96.8	13.3	56	132.8	24.4	76	168.8	35.6	96	204.8
-34.4	-30	-22	-8.33	17	62.6	2.78	37	98.6	13.9	57	134.6	25.0	77	170.6	36.1	97	206.6
-28.9	-20	-4	-7.78	18	64.4	3.33	38	100.4	14.4	58	136.4	25.6	78	172.4	36.7	98	208.4
-23.3	-10	14	-7.22	19	66.2	3.89	39	102.2	15.0	59	138.2	26.1	79	174.2	37.2	99	210.2
-17.8	0	32	-6.67	20	68.0	4.44	40	104.0	15.6	60	140.0	26.7	80	176.0	37.8	100	212.0
-17.2	1	33.8	-6.11	21	69.8	5.00	41	105.8	16.1	61	141.8	27.2	81	177.8	43	110	230
-16.7	2	35.6	-5.56	22	71.6	5.56	42	107.6	16.7	62	143.6	27.8	82	179.6	49	120	248
-16.1	3	37.4	-5.00	23	73.4	6.11	43	109.4	17.2	63	145.4	28.3	83	181.4	54	130	266
-15.6	4	39.2	-4.44	24	75.2	6.67	44	111.2	17.8	64	147.2	28.9	84	183.2	60	140	284
-15.0	5	41.0	-3.89	25	77.0	7.22	45	113.0	18.3	65	149.0	29.4	85	185.0	66	150	302
-14.4	6	42.8	-3.33	26	78.8	7.78	46	114.8	18.9	66	150.8	30.0	86	186.8	71	160	320
-13.9	7	44.6	-2.78	27	80.6	8.33	47	116.6	19.4	67	152.6	30.6	87	188.6	77	170	338
-13.3	8	46.4	-2.22	28	82.4	8.89	48	118.4	20	68	154.4	31.1	88	190.4	82	180	356
-12.8	9	48.2	-1.67	29	84.2	9.44	49	120.2	20.6	69	156.2	31.7	89	192.2	88	190	374
-12.2	10	50.0	-1.11	30	86.0	10.0	50	122.0	21.1	70	158.0	32.2	90	194.0	93	200	392
-11.7	11	51.8	.056	31	87.8	10.6	51	123.8	21.7	71	159.8	32.8	91	195.8	99	210	410
-11.1	12	53.6	0	32	89.6	11.1	52	125.6	22.2	72	161.6	33.3	92	197.6	100	212	413
-10.6	13	55.4	.056	33	91.4	11.7	53	127.4	22.8	73	163.4	33.9	93	199.4	104	220	428
-10.0	14	57.2	1.11	34	93.2	12.2	54	129.2	23.3	74	165.2	34.4	94	201.2			
-9.44	15	59.0	1.67	35	95.0	12.8	55	131.0	23.9	75	167.0	35.0	95	203.0			

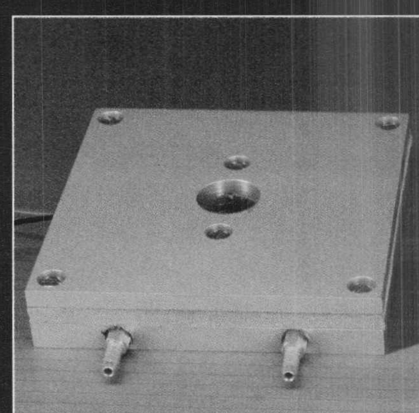
MM.	IN.	MM.	IN.
1	0.039370	26	1.023622
2	0.078740	27	1.062992
3	0.118110	28	1.102362
4	0.157480	29	1.141732
5	0.196850	30	1.181102
6	0.236220	31	1.220472
7	0.275591	32	1.259843
8	0.314961	33	1.299213
9	0.354331	34	1.338583
10	0.393701	35	1.377953
11	0.433071	36	1.417323
12	0.472441	37	1.456693
13	0.511811	38	1.496063
14	0.551181	39	1.535433
15	0.590551	40	1.574803
16	0.629921	41	1.614173
17	0.669291	42	1.653543
18	0.708661	43	1.692913
19	0.748031	44	1.732283
20	0.787402	45	1.771654
21	0.826772	46	1.811024
22	0.866142	47	1.850394
23	0.905512	48	1.889764
24	0.94882	49	1.929134
25	0.984252	50	1.968504

NOMENCLATURE/SYMBOLOGY

I	Electrical [Amperes].
Q	Heat absorption or heat generation [Watts].
Q_C	Heat flow at the cold side of a couple (or module), generally absorption [Watts].
Q_H	Heat flow at the hot side of couple (or module), generally rejection [Watts].
T_C	Temperature of a body attached right next to the cold side of a thermoelectric couple (or module) with zinc oxide loaded silicon grease [C].
T_H	Temperature of a body attached right next to the cold side of a thermoelectric couple (or module) with zinc oxide loaded silicon grease [C].
T_a	Temperature of the Ambient immediatly surrounding a thermoelectric device [C].
ΔT	ΔT = Th - Tc [C].
V	Voltage drop across a thermoelectric module in operatiion (input or output voltage) [Volts].
X	Insulation thickness [ft].
Q_A	Active heat load
Q_{HL}	Heatload due to natural convection and radiation.







INNOVATIONS IN THERMAL TECHNOLOGY

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